Preparation SIC Powder and Filler as Heat-Conducting Glue Based on Near Field Radiation

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Abstract: (Objective)to reduce the thermal resistance and junction temperature on high power LED, Quantity of heat made by the PN junction can break through bottlenecks to improve the luminous efficiency, reliability and life of the product. (Methods)Minuteness SiC powder is be made using plasma reaction, chemical precipitation method and so on. Then, they have high surface energy including stable thermal, chemical and electrical properties using the surface modification technology. (Results)Under the guidance of the mechanism on heat transfer and radiation in the near-field, the SiC powder is be stimulated on the near-field thermal resonance at room temperature in order to improve thermal conductivity between particles. The synthesis such as thermal conductive glue, thermal conductive adhesive tape, caulking materials and pouring sealant can be widely used in LED encapsulation and lamps. (Conclusion) SIC powder and filler can continuously improve performance of heat dissipating on all kinds of plastic and powder.

1. Introduction

In LED encapsulation and lamps, the LED chips are fixed with bonding material. In other LED production process, there are some links implemented on colloid. Common thermal conductive adhesive have bonding material, conductive silver pulp or tin pulp. Common gel associated with heat dissipation contain caulking material, thermal grease, thermal conductive adhesive tape, potting glue, insulation gasket and thermal conductive silicone, etc.

The thermal conductive adhesive of conductive type has high thermal conductivity, has good bond strength. Its disadvantage is the high cost, and it does not separate between circuit and thermal road, also does not be used in some occasions. The thermal conductive adhesive of insulating type lied in colloid contain a large number of thermal resistance of high polymer material, therefore thermal conductivity relatively have low coefficient. Bonding materials directly contact to chips, so the thermal conductivity coefficient of bonding material will directly affect the heat dissipation capacity of the LED.

2. Heat Transfer Mechanisms of the Resonance on Near Field Radiation

The electrons in the atoms which made up all objects always are doing thermal motion, so they are Continuously radiating electromagnetic waves. This radiation is common thermal radiation known as the far field radiation. In addition to this radiation, electron charge itself also has the coulomb field. Due to the strength of the coulomb field is inversely proportional to the square of the distance between charges, electric field intensity attenuation speed is very fast after leaving the surface, only in extremely close range it has obvious effect, so the electric field is known as the near field [1]. The near field energy exchange is referred to as the near field radiation. According to the research and experiment, in the process of the near field radiation, the energy exchange is higher several magnitudes than the far field radiation. Using heat dissipation of the radiation, current exchange coefficient of heat conduction on the glue can increase several magnitudes.

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During the entire cooling process on LED, the heat transfer goes through three parts. The first part is the heat source of the LED chip. The main direction of research is how to reduce the rate of heat generation rate, so energy can concentrate more on light, luminous efficiency is improved. It is difficult to have greatly improved because the technology is already close to maturity stage.The second part is to conduct the heat produced by the chip to the third part. This part can be divided into two steps, the first step is to transfer the heat produced by the p-n junction inside the chip to the epitaxial layer, the second step is conduct heat process of packaging substrate from epitaxial layer. How to put effectively heat transfer out is goals we want to achieve. The third part is the cooling system with which transfers mainly heat into the air or water cooling medium by convection, radiation and other more effective ways. Active cooling often is used of artificial equipment such as fan that can transfer heat mandatorily to the cooling medium away.

Heat transfer mechanisms of the resonance radiation on near field are mainly utilizing the particle surface level (electromagnetic energy level) to match with thermal excitation energy KBT of room temperature. Near field electromagnetic field can generated intensively in the particle surface, even tunneling effect (correspond with electronic tunneling effect) can take place between particles of intense photon when the distance between the two particles is smaller than a certain length (about 10 microns), to result in the near field resonance radiation heat transfer [2, 3]. In LED heat conduction glue， heat transfer mechanisms of the resonance radiation in the near field is used to improve the heat conduction glue between the filler particles in the thermal conductivity, so as to improve the overall thermal conductivity of thermal conductive adhesive. The concrete is shown in Fig. 1.

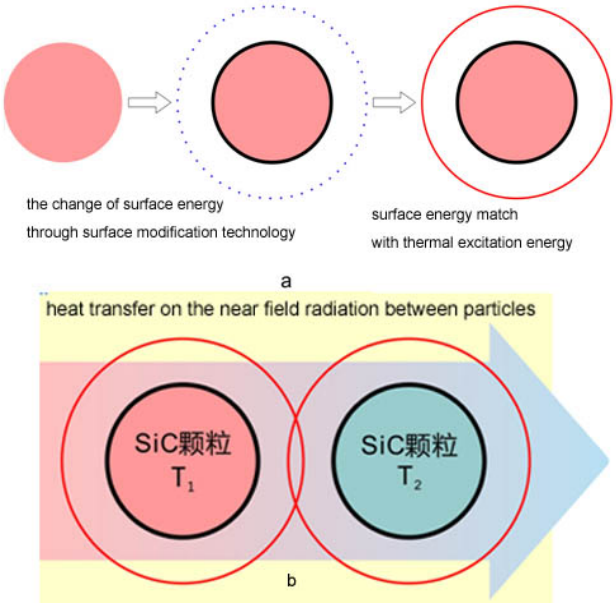

Figure 1. Heat transfer on the near field radiation between particles

According to the theoretical calculation, the radiation heat exchange efficiency is six times inverse proportion to the distance. So the distance is closer, near field resonance radiation heat transfer is better. Its heat transfer effect can be much higher than the usual heat conduction at room temperature. In addition to the influence of the distance, the polarizability of material has very important influence. Some material provided with surface wave effects, such as SiC, has a special dielectric constant. While these material particles get very close to each other, they may produce intense radiation heat transfer. According to the near-field radiation heat exchange coefficient of SiC particles are close to the coefficient of thermal conductivity of water [4].

Application of plasma reaction method can produce nanometer SiC line by adjusting the gas partial pressure or to control the morphology of SiC reaction by introducing templates. Then the surface state of SiC line is changed or modified by applying the surface modification technology in order to make high surface energy. The near resonance realizes the near field radiation heat transfer through between the nanowires/powder on room temperature thermal excitation to improve thermal

conductivity between SiC particles and good thermal conductivity (thermal conductivity > 5W/m/s).The thermal conductive adhesive was applied to the LED lamp bead encapsulation to break through the lamp beads heat bottlenecks and to product high-power LED lamps and lanterns.

3. The Main Research Contents and Experimental Methods

Plasma that made up of charged particles and neutral particles is an ionized conductive gas. When the plasma of substances that is in a state for the raw material for reaction has good activity, it can be obtained with good nano product quality. Generally plasma methods have dc arc plasma method, dc plasma jet method, double rf plasma method and hybrid plasma method. Dc arc plasma method is commonly used as preparation methods of nano-materials. Its working principle is as follows: under inert gas protection or reactive atmosphere by dc discharge, high temperature plasma arc is produced. High temperature arc come to contact with the raw material surface, raw material will be heated evaporation. the gas particles into evaporation are very small particles of raw materials, it can react with reaction atmosphere to form uniform particles. Nano-particles made in this way have pure components, particle uniformity, easy dispersibility, good surface activity and reactivity.

Surface modification technology refers to a material on the substrate surface of the physical and chemical method, is used to change the material chemical composition or structure in order to improve the material performance, in order to meet the needs of the development of new technology of modern new technology. To surface modification of ultrafine powders, common ways have surface coating modification, surface chemical modification, chemical modification of mechanical force, high energy modification and deposition modification, etc. In deposition modification precipitating agent is added to a solution containing the powder particles to make precipitation reaction of the modified ion and separate out the surface of particles in order to coat particles to change the material properties, such as the change of surface energy, surface electrical and so on.

4. The Process Flow

4.1. Preparation of SiC powder

SiC powder prepared by using reaction of plasma. The preparation process is under inert gas protection, the total pressure is 8 x 104 Pa, voltage is 20 ~ 28 v, the condition of current is 60 ~ 62 a, SiC nanometer powder prepared by dc arc plasma. The second way is to get aqueous solution of SiC by using the template method and sol-gel method. The next step is to compare the advantages and disadvantages of the two kinds of method (from cost, production, performance, etc), and to improve technology processing of SiC nanometer powder.

4.2. Surface modification of SiC nanometer powder

On the surface of SiC nanometer powder single semiconductor materials are covered using chemical precipitation, such as Doping tin oxide that has a few nanometers thickness will change the SiC conductance, carrier concentration and the resonance frequency of surface plasma. Or using monolayer strong polarity ways that will change the surface level conductive molecular, to make it match thermal radiation energy under the room temperature. So, the radiative heat transfer on the near field between the surfaces of particles will realize to improve the heat transfer between the particles.

4.3. To select the appropriate binder

Selection of adhesive must be satisfied: the near field resonance of the SiC nanometer powder can happen effectively under index of binder dielectric constants and refractive, under the room temperature thermal excitation of the SiC nanometer powder in the formation medium that is cured in near field electromagnetic field range is large enough, at the same time, the formation of the medium cured in near field electromagnetic is less absorption (i.e., low dissipation).On the silicone resin series that chosen relatively satisfy the condition, after SiC nanometer powder and binder were

mixed, the experiments using field (alternating shear strain or electric field) induced ordering process to form into mixed the texture adhesive ,to improve the ability of thermal conductivity[5].

5. Conclusions

Surface modification technology used by the project can also be used to the aluminum base material. Nitrogen treatment to the aluminum nitride substrate can make AlN instead of aluminum substrate alumina. Protection using of diamond-like films can improve thermal conductivity aluminum substrate interface, and improve the aluminum plate heat sink.

Nanometer SiC powder can be prepared using plasma reaction, chemical precipitation method. These powders will have high surface energy using the surface modification technology, and have appropriate mechanical, thermal, electrical and chemical properties. It is difficult to modify properties on the surface of the filling material, not only to realize the near resonance radiation heat transfer and to control of process parameters such as filling material shape, but also to reduce the amount of contact between particles. The next research is how to increase the contact area and improve the heat dissipation structure and technology.

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